

AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph beginning at page 2, line 13, with the following amended paragraph:

In the drawing, ~~a numerical reference 2~~ notation AM2 designates an upper arm AM, ~~[[a]]~~ numerical reference 3 designates a load, ~~[[a]]~~ numerical reference 84 designates a main bearing built in a reduction device mechanism, ~~[[a]]~~ numerical reference 100 designates a large gear, and ~~[[a]]~~ numerical reference 103 designates a small gear. Notation S designates a rotating shaft (first shaft), and a rotating head RH is horizontally rotated centering on the vertical shaft S. Notation L designates a front/rear shaft (second shaft) and a ~~[[first]]~~ lower arm AM1 is pivoted back and forth ~~[[with]]~~ centering on the horizontal shaft L. Notation U designates an up/down shaft (third shaft), and the ~~second~~ upper arm AM2 is pivoted up and down with centering on the horizontal shaft U.

Please replace the paragraph beginning at page 3, line 5, with the following amended paragraph:

Further, in a state of operating the robot, an inertia force or a centrifugal force might be generated, ~~which will be the load to the main bearing 84 as a~~ and the dynamic moment in accordance with mass, acceleration, velocity or the like will be applied to the main bearing 84.

Please replace the paragraph beginning at page 3, line 24, with the following amended paragraph:

Although the robot can take an arbitrary attitude, a direction of the moment being applied can be predictable. The gravitational force moment applied to the main bearing 84 of the rotating shaft is always applied ~~in a plane of rotating~~ around an axis in parallel with the front/rear shaft.

Also the dynamic moment and the emergency moment are always applied in the plane of rotating the front/rear shaft when the front/rear shaft and the up/down shaft are applied. Although in the case of operating the rotating shaft and a wrist shaft, there is a case in which the dynamic moment is not applied in the plane of rotating the front/rear shaft, an absolute value thereof is small and is negligible in comparison with the dynamic moment in operating the front/rear shaft and the up/down shaft.

Please replace the paragraph beginning at page 4, line 13, with the following amended paragraph:

As is known from the drawing, operation of the robot is normally carried out in the area as shown in Fig.6, whereby normally the load such as the gravitational force moment is not applied to the main bearing of the front/rear shaft in view of an attitude of the operation. Further, in an operating state of the front/rear shaft and the up/down shaft, any dynamic moment or emergency moment might not be applied. It is in a state of operating the rotating shaft that a moment is generated ~~in a rotating plane including the work area.~~

Please replace the paragraph beginning at page 4, line 25, with the following amended paragraph:

Now, as shown by Fig.7(b), in the case of arranging a small gear at a position a of an outer periphery of the large gear where a moment is applied ~~in a direction orthogonal to a direction of connecting~~ around the axes passing the respective center[[s]] points of the large gear and the small gear, a circumferential direction backlash β is expressed as shown below when a width in an axial

direction of a gear is designated by notation B (Fig.7(a)) and an angle of falling the gear is designated by notation θ .

Please replace the paragraph beginning at page 7, line 8, with the following amended paragraph:

In order to achieve the above-described object, the invention 1 relates to a reduction device of an industrial robot having a robot base installed in an XY plane of XYZ orthogonal coordinates, a rotating barrel portion rotatably attached to the robot base, and a lower arm of which one end in axially supported by the rotating barrel portion, which is a rotating shaft and a front/rear shaft. ~~Further, the rotating shaft of said reduction device of an industrial robot including at least one stage of a gear train where is characterized by a large gear with its position being fixed to the robot base[[,]] and a small gear which is axially supported in the rotating barrel portion and brought in mesh with the large gear, wherein the large gear and the small gear are arranged at a vicinity of a rotational plane of the front/rear shaft each other;~~ wherein the small gear is arranged by determining an angle of arranging the small gear, centering on a rotating shaft of the large gear within a range in which a circumferential direction backlash amount of the small gear becomes equal to or smaller than that of the large gear in a state of being inclined around an axis, which is connecting rotational centers of the large gear and the small gear in the XY plane owing to an operation of rotating the lower arm, in a state of arranging the small gear such that the axis passing the respective rotational center points of the large gear and the small gear in the XY plane is orthogonal to a plane of operating to rotate the lower arm.

Please replace the paragraph beginning at page 7, line 18, with the following amended paragraph:

The invention 2 relates to a reduction device of an industrial robot characterized in a reduction device of an industrial robot having a robot base arranged in an XY plane of XYZ orthogonal coordinates, a rotating barrel portion, ~~a rotating shaft and a front/rear shaft~~. Moreover, ~~the rotating shaft of the reduction device is characterized by a small gear axially supported by the robot base, and a large gear which is brought in mesh with the small gear with its position being fixed to the rotating barrel portion, wherein the large gear and the small gear are arranged at a vicinity of a rotational plane of the front/rear shaft~~ rotatably attached to the robot base, and a lower arm one end of which is axially supported by the rotating barrel portion, which is a reduction device of an industrial robot comprising at least one stage of a gear train at which a small gear axially supported by the robot base and a large gear fixed in the rotating barrel portion are brought in mesh with each other, wherein the small gear is arranged by determining an angle of arranging the small gear centering on a rotating shaft of the large gear within a range in which a circumferential direction backlash amount of the small gear becomes equal to or smaller than a circumferential direction backlash amount when the large gear is inclined around an axis of connecting rotational centers of the large gear and the small gear in the XY plane owing to an operation of rotating the lower arm in a state of arranging the small gear such that the axis passing the respective rotational center points of the large gear and the small gear in the XY plane is orthogonal to a plane of operating to rotate the lower arm.

Please replace the paragraph beginning at page 8, line 2, with the following amended paragraph:

The invention 3 relates to a reduction device of an industrial robot ~~having a robot base~~
characterized in a reduction device of an industrial robot having a robot base installed in an XY
plane of XYZ orthogonal coordinates, a rotating barrel portion, a rotating shaft and a front/rear
shaft. Further, the front/rear shaft of the reduction device is characterized by a large gear with its
position being fixed to rotatably attached to the robot base, a lower arm of the robot, a small gear
one end of which is axially supported [[in]] by the rotating barrel portion, and brought in mesh with
the large gear, and an up/down shaft which is pivotably supported axially by and an upper arm one
end of which is axially supported by other end of the lower arm, wherein the large gear and the
small gear are arranged at a vicinity of a plane passing a rotational center axis of the up/down shaft
and in parallel with a rotational plane of the rotating shaft which is a reduction device of an
industrial robot comprising at least one stage of a gear train at which a large gear fixed to the lower
arm and a small gear axially supported in the rotating barrel portion are brought in mesh with each
other, wherein the small gear is arranged by determining an angle of arranging the small gear
centering on a rotating shaft of the large gear within a range in which a circumferential direction
backlash amount of the small gear becomes equal to or smaller than a circumferential direction
backlash amount when the large gear is inclined around an axis of connecting rotational centers of
the large gear and the small gear in the XY plane owing to an operation of rotating the rotating
barrel portion in a state of arranging the small gear such that the axis of passing the respective
rotational center points of the large gear and the small gear in the XY plane becomes in parallel
with a rotating shaft of the rotating barrel portion.

Please replace the paragraph beginning at page 8, line 14, with the following amended paragraph:

The invention 4 is characterized in ~~including a through hole at a center portion of the large gear in the reduction device of an industrial robot described in the invention 1, 2 or 3~~ that the gear train of the reduction device is constituted by two stages in the reduction device of an industrial robot described in any one of the invention 1 through 3.

The invention 5 is characterized in that the gear train of the reduction device is constituted by one stage in the reduction device of an industrial robot described in any one of the invention 1 through 3.

The invention 6 is characterized in that a center portion of the large gear includes a communication hole in the reduction device of an industrial robot described in any one of the invention 1 through 5.

Please replace the paragraph beginning at page 8, line 18, with the following amended paragraph:

~~As for the~~ The cases of the reduction devices of (1) through (3), they might be described in the invention 1 through 6 are equivalent to a case in which the small gear is arranged at a position b shown in Fig.7 and a moment is applied in a direction ~~the same as a direction of connecting respective centers~~ of inclining a large gear in a plane including rotational center lines of the large gear and the small gear.

Please replace the paragraph beginning at page 9, line 21, with the following amended paragraph:

When k is put as follows and α is set to $\alpha = 14.5$ degrees, a relationship between k and β becomes as shown by Fig.10.

$$k = \cos\beta + 2\tan\alpha \times B\sin\beta$$

Please replace the paragraph beginning at page 10, line 3, with the following amended paragraph:

Next, according to the reduction device of an industrial robot as described in [(4)] Invention 6, the output stage becomes a constitution capable of reducing the backlash by using the gear train. Therefore, in comparison of the reduction device mechanism of a rotating type, a center portion is only provided with the communication hole where the main bearing having an optimum load capacity can be selected.

Please replace the paragraph beginning at page 12, line 22, with the following amended paragraph:

Fig.3 is a view showing Example 1 and is a sectional view taken along a line A-A of Fig.1. The drawing shows the invention 2 and the invention 4. As shown by the drawing, the large gear 100 and the small gear 103 are arranged orthogonally to a rotation center axis (illustrated by a one-dotted chain line) of a ~~second shaft (front/rear shaft[()])~~ (second shaft). An outer ring of the main bearing 84 (Fig.1) is mounted to the rotating barrel portion members 102, 104, while an inner ring thereof is mounted to the output shaft 33 fixed to the robot base 10. In general, the main bearing 84 is constituted by a combination of two pieces thereof having the working angle opposed

to each other, and when a moment load is applied thereto, inside of the main bearing is elastically deformed to produce a misalignment between a center of the inner ring and a center of the outer ring. Moments generated from the upper/lower shaft and the front/rear shaft change relative positions of the rotating barrel portion members 102, 104 relatively to the output shaft 33. The same can be said to a cross roller bearing for supporting a moment load by a single bearing. Therefore, since the small gear 103 is axially supported by the rotating barrel portion members 102, 104, an interval between axes of the large gear 100 and the small gear 103 is changed.

Please replace the paragraph beginning at page 13, line 19, with the following amended paragraph:

Now, ~~since the moment is applied only to the~~ in a direction of inclining the large gear in
a plane including rotational center lines of the small gear 103 and the large gear 100 and therefore,
~~the changing amount of the~~ an amount of changing a circumferential direction backlash ~~in a~~
~~circumferential direction occurring at the small gear 103 and of the large gear 100 and the small~~
~~gear 103 might be~~ becomes smaller than that at other arrangement position. ~~As to the rotational~~
~~center of~~ In order to achieve an effect of the invention, the small gear 103, ~~it can be provided may~~
be arranged at any position within 35 degrees in a left and right ~~centering on~~ direction around the
rotational center of the large gear 100 ~~and the small gear 103 in order to achieve an effect of the~~
~~invention~~ (incidentally, a gear pressure angle is 14.5 degrees). Although a gear train of the
reduction device is constituted by two stages (input stage and output stage), the same can be
employed for a gear train having three or more stages.

Please replace the paragraph beginning at page 14, line 7, with the following amended paragraph:

[[A]] The rotational center portion of the large gear 100 is opened with a communication hole 101 for arranging a wire-like member. Although in this case, the wire-like member is constituted by the cable CB for feeding electricity to a square shaft driving motor, a single piece of a wire-like member or two or more pieces of wire-like members including various cables or pipes of other object will do. In arranging such a wire-like member, any interference likely to happen in accordance with rotating are excluded. Further, an outer periphery of a hollow portion may be arranged only at the output shaft 33 for fixing the outer ring of the main bearing and therefore, a reduction in cost can be carried out since a necessary minimum bearing can be selected without being restricted by a dimension of the inner ring.

Please replace the paragraph beginning at page 15, line 9, with the following amended paragraph:

As shown by Fig.4, the large gear 100a and the small gear 25a are arranged ~~in a plane in parallel with the rotating shaft rotating plane including a rotational center axis of the second shaft (front/rear shaft)~~ orthogonally to the rotating shaft in an XZ plane. An outer ring of main bearing 84a is mounted to the rotating barrel portion members 115, 116, and an inner ring thereof is mounted to the output shaft 33a fixed to the lower arm AM1. In general, the main bearing 84a is constituted by the combination of two pieces thereof having working angle opposed to each other and when the moment load is applied thereto, inside of the bearing is elastically deformed to produce a misalignment between a center of the inner ring and a center of the outer ring. A

moment generated from operation of the rotating shaft changes relative positions of the rotating barrel portion members 115, 116 relatively to the output shaft 33a. Therefore, since the small gear 103a is axially supported by the rotating barrel portion members 115, 116, an interval between axes of the large gear 100a and the small gear 103a is changed. More overly, a moment is hardly generated or almost negligible value in the main bearing 84a by forces generated when the up/down shaft and the front/rear shaft are driven, or when the front/rear shaft and the up/down shaft remains stationary. This is because a static/dynamic load loading distributions of the ~~front/rear shaft and the up/down shaft are ordinarily~~ is disposed ordinarily in an operating line of the main bearing 84a or at a vicinity thereof.

Please replace the paragraph beginning at page 16, line 9, with the following amended paragraph:

Now, ~~since the moment is applied only around the~~ in a plane including rotational center lines of the small gear 103a and the large gear 100a, ~~therefore, the changing amount of the backlash~~ in a moment generated by operating the rotating shaft is applied in a direction of inclining the large gear and therefore, an amount of changing the circumferential direction occurring at back lash of the large gear 100a and the small gear 103a ~~might be~~ becomes smaller than that at other arrangement position. ~~As to~~ In order to achieve the effect of the invention, the small gear 103a, ~~it can be provided~~ may be arranged at any position within 35 degrees in ~~the~~ the left and right direction ~~in order to achieve an effect of the invention~~ around the rotational center of the large gear 100a (incidentally, the gear pressure angle is 14.5 degrees). Although ~~the~~ the gear train of the reduction device is constituted by two stages (input stage and output stage), the same can be employed for ~~the~~ the gear train having of three or more stages.